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TRAFFICABILITY TESTS WITH JUMBO TRUCK ON
ORGANIC AND COARSE-GRAINED MINERAL SOILS

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Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

July 1961

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U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS.

Preface

The trafficability tests with the Jumbo truck reported herein were authorized by the Office, Chief of Engineers, by telephone conversation 18 July 1960, and were conducted at Fort Custer, Michigan, and at Warren Dunes State Park near Bridgman, Michigan, during the period 3-10 October 1960 by personnel of the Army Mobility Research Center, Waterways Experiment Station, under the general supervision of Messrs. W. J. Turnbull, Chief of the Soils Division, S. J. Knight, Chief of the Army Mobility Research Center, and A. A. Rula, Chief of the Trafficability Section. Mr. E. S. Rush of the Trafficability Section supervised the field testing and prepared this report.

Acknowledgment is made to the District Engineer, U. S. Army Engineer District, Detroit, for loan of the vehicle and crew, and to Mr. Julius Grigore, Jr., of the U. S. Army Engineer District, Detroit, who was project engineer in charge of the development and fabrication of the vehicle and who acted as liaison officer.

Col. Edmund H. Lang, CE, was Director of the Waterways Experiment Station during the field testing and preparation of this report. Mr. J. B. Tiffany was Technical Director.

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Summary

Trafficability tests were conducted in soft muck and clean sand to determine the performance characteristics of the Jumbo, a 5-ton (M704) 4x4 truck fabricated from commercially available parts and equipped with large construction-equipment-type tires. Performance in muck, measured in terms of minimum soil strength in the critical layer required for 40 to 50 passes of the vehicle (vehicle cone index), was compared with its predicted performance computed from the WES mobility index formula for determining vehicle cone index of wheeled vehicles in fine-grained soils. Performance in sand, measured in terms of maximum slope negotiable and soil strength in the critical layer, was compared with the performance of an M135 2-1/2-ton 6x6 truck. Results of the tests in muck indicated that the Jumbo could complete 40 to 50 passes on a rating cone index of 56, several points lower than that required for wheeled military vehicles of similar weights. On a cone index of 49 (the vehicle cone index), it could complete about 24 passes. Results of the sand tests indicated that the Jumbo has better slope-climbing ability than the M135 truck at the same tire pressures. Further tests in soft mineral soils and soft snow are recommended to evaluate the vehicle further and to determine if the mobility index formula for similar types of wheeled vehicles should be modified. The computations for determining the mobility index and vehicle cone index of the Jumbo truck for operation in fine-grained soils are presented in Appendix A.

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TRAFFICABILITY TESTS WITH JUMBO TRUCK ON ORGANIC
AND COARSE-GRAINED MINERAL SOILS

Introduction

1. The Jumbo truck equipped with a drill rig is used by the U. S. Army Engineer District, Detroit, to collect subsoil samples in foundation and earth embankment investigations. Drilling sites are often widely dispersed and usually not readily accessible; hence a vehicle is needed that can travel on roads at moderate speeds and can also travel cross country. Since studies conducted by the Army Mobility Research Center were considered in the fabrication of the Jumbo,* determination of its off-road performance was of extreme interest to the AMRC.

The Vehicle

2. The 5-ton Jumbo (M704) 4x4 truck, shown in fig. 1, was fabricated

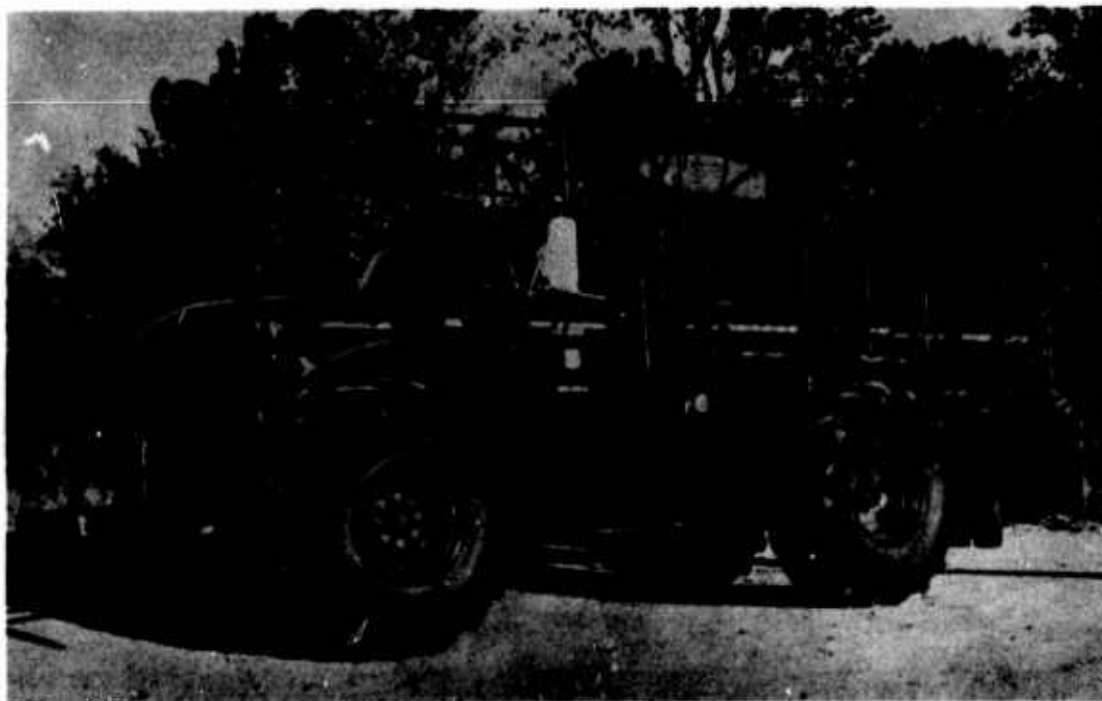


Fig. 1. The 5-ton Jumbo (M704) 4x4 truck

* Julius Grigore, Jr., "The Jumbo truck," The Military Engineer, vol 51, No. 343 (Sept-Oct 1959), pp 385-388.

from commercially available parts with the truck chassis modified to accommodate large construction-equipment-type tires. A drill rig and accessory equipment were installed in the cargo space. The truck also has torque proportioning differentials.

3. Pertinent vehicle data are:

Vehicle weight, lb	20,100
Front axle	6,100
Rear axle	14,000
Tires	
Size	18.00-26 10-PR
Type	Construction equipment, diagonal tread
Total contact area,* sq in.	
At 30-psi inflation pressure	746
At 20-psi inflation pressure	827
At 15-psi inflation pressure	956
At 10-psi inflation pressure	1,163
Ground clearance, in.	16.5
Engine horsepower	160
Transmission	Mechanical
Computed vehicle cone index	49

* From contact prints made on a hard surface.

Purpose and Scope of Test Program

4. The purpose of the test program reported herein was to determine the performance of the Jumbo in muck and sand, two soil types readily available for the tests. Its performance in muck, measured in terms of minimum soil strength in the critical layer† required for 40 to 50 passes of the vehicle (vehicle cone index), was compared with its computed performance in fine-grained soil derived from the formula (see Appendix A) for determining the mobility index of wheeled vehicles in fine-grained soils.†† Its performance in sand, measured in terms of maximum slope negotiable and soil strength in the critical layer,† was compared with the

† For wheeled vehicles of up to 50,000-lb gross weight, the 6- to 12-in. layer is considered the critical layer in fine-grained soils, and the 0- to 6-in. layer is considered critical in clean sands.

†† U. S. Army Engineer Waterways Experiment Station, CE, Trafficability of Soils, A Summary of Trafficability Studies Through 1955, Technical Memorandum No. 3-240, 14th Supplement (Vicksburg, Miss., December 1956).

performance of an M135 2 1/2-ton 6x6 truck, a vehicle of comparable size (weight).

Test Areas and Soil Properties

Test areas

5. The test areas were located near Harts Lake on the Fort Custer Reservation near Battle Creek, Mich., and at Warren Dunes State Park near Bridgman, Mich. (see fig. 2). Portions of the test areas are shown in figs. 3 and 4.

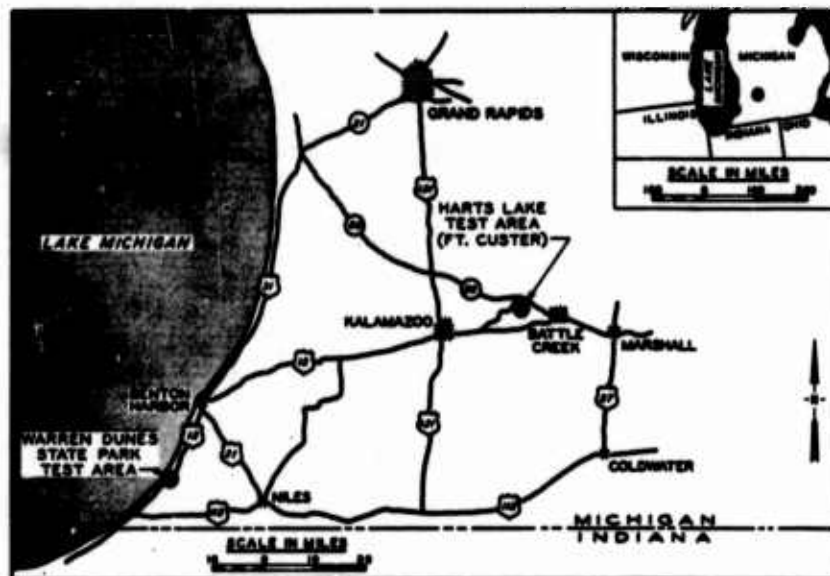


Fig. 2. Location of test areas.



Fig. 3. Muck test area near Harts Lake, Fort Custer Reservation, Mich.



Fig. 4. Sand test area, Warren Dunes State Park, Mich.

Soils

6. Muck. Muck is decomposed or partly decomposed organic matter mixed with varying, though usually small, quantities of sand and silt. The muck soil tested contained 28.4% organic matter on a dry-weight basis, as determined by the "loss by ignition" method. Moisture contents ranged from 56 to 394%, and dry densities ranged from 14 to 63 lb per cu ft. Liquid limit of the soil in the 0- to 12-in. layer averaged 130, and the plasticity index was 63. It was impractical to determine the gradation of the muck because of the large particles of organic matter and fibrous roots and stems of undecomposed material; however, it was treated as fine-grained soil for test purposes. The muck varied in depth from 12 to 24 in. and deeper, and was underlain by a sand mixture classified according to the Unified Soil Classification System as medium to fine sand (SP) with some fines and organic matter. Gradation curve for the sand mixture is shown in fig. 5.

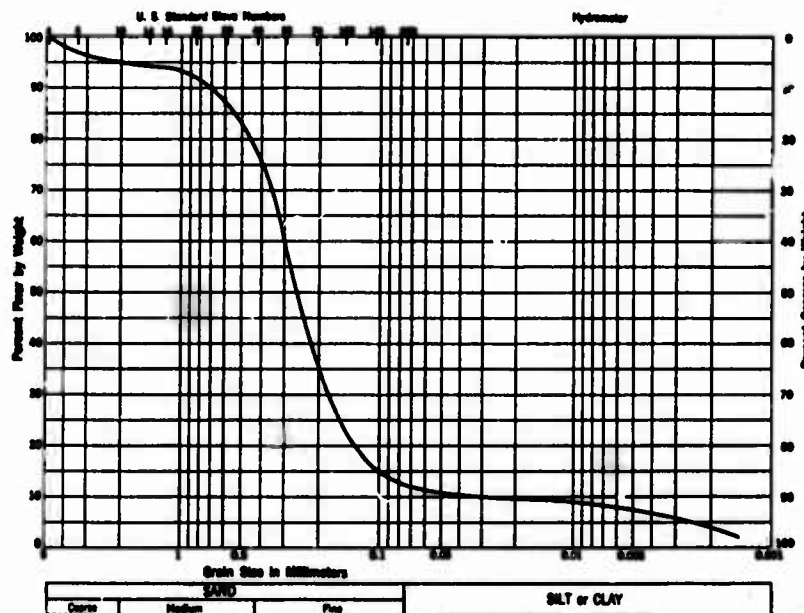


Fig. 5. Gradation curve of soil (SP with fines) below muck, Harts Lake

7. Clean sand. A gradation curve for the dune-area sand at Warren Dunes State Park is shown in fig. 6. The soil is classified as a uniformly graded fine sand (SP) with no fines present. All trafficability tests were performed on slopes of unstabilized dunes.

Test Procedures and Data

Muck tests

8. Eight tests in muck were conducted by running the vehicle back and forth in a 100-ft-long path, selected for each test, until it became immobilized or had completed 40 passes and immobilization did not seem imminent. Because the front of the Jumbo truck contained suitable towing hitches to which a towing cable could be attached in case it became immobilized, the truck entered the test lane in reverse so that the front of

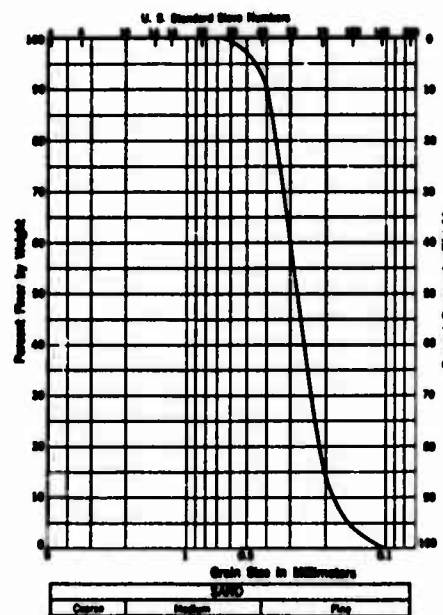


Fig. 6. Average gradation curve for sand, Warren Dunes State Park

the vehicle faced nearby firm ground on which the retrieving vehicle operated. Therefore the first pass and every odd-numbered pass thereafter were made in reverse gear. Tire pressure for all muck tests was 30 psi.

9. At the beginning of each test, the 100-ft-long test lane was staked out, and the cone index* of the soil was measured at 5-ft intervals along the anticipated center line of the vehicle path. Measurements were made at the surface and at 3-in. vertical increments to a depth of 24 in. Two remolding index* tests were then made near the point where the lowest cone index was measured. Samples for moisture-content and density determinations were taken from the 0- to 6-in. and 6- to 12-in. depths at each remolding index station. After these tests were completed, traffic was begun. Rut depths were measured at various intervals during traffic. Also, observations were made of the behavior of the soil and vehicle. The data and test results are summarized in table 1.

Sand tests

10. Thirty-six tests in sand were conducted by running the Jumbo up preselected sand slopes until it became immobilized or until it reached the top of the slope. Four tire-inflation pressures (30, 20, 15, and 10 psi) were used in the sand tests.

11. Soil data were collected after completion of the vehicle traffic. If the vehicle became immobilized, data were collected from both sides of the immobilized truck. If the vehicle was not immobilized, data were collected adjacent to the steepest section of the slope the vehicle had negotiated. Cone indexes and moisture-content data were collected outside the zone of disturbance by the truck, and are considered to be "before-traffic" data for analysis purposes. A set of cone index readings consisted of measurements made at the surface and at 3-in. vertical increments to a depth of 18 in. or to a depth at which the capacity of the cone penetrometer (300) was reached. Ten sets of cone index readings usually were made for each test, five on each side of the truck. Only a limited number of moisture-content measurements were made, but the moisture content of the sand was visually estimated for each test. Density measurements were not made; however, density was estimated to be 85 to 90 lb per cu ft. Tire-inflation

* Defined in Waterways Experiment Station report, op. cit.

pressures and sand slopes were measured carefully before each test. Pertinent notes describing the action of the vehicle during each test were recorded. The data and test results are summarized in table 2.

Test Results

Muck tests

12. The principal purpose of the tests conducted in muck was to determine experimentally the rating cone index (in the 6- to 12-in. depth) required for the Jumbo to negotiate 40 or more passes in a straight line on level soil. This experimentally determined vehicle cone index was then compared with the computed vehicle cone index (49) (see Appendix A).

13. Determination of experimental vehicle cone index. Of the eight tests conducted in the muck area to determine the "experimental" vehicle cone index for the Jumbo, six resulted in immobilization. In two of the tests in which immobilization occurred the vehicle was able to complete more than 24 passes before becoming immobilized. Test data are summarized in table 1 and test results are shown graphically in fig. 7.

14. From fig. 7 it is seen that a line drawn at a rating cone index of 56 divides immobilizations from nonimmobilizations. From these data, the experimental vehicle cone index is thus 56. It is interesting to

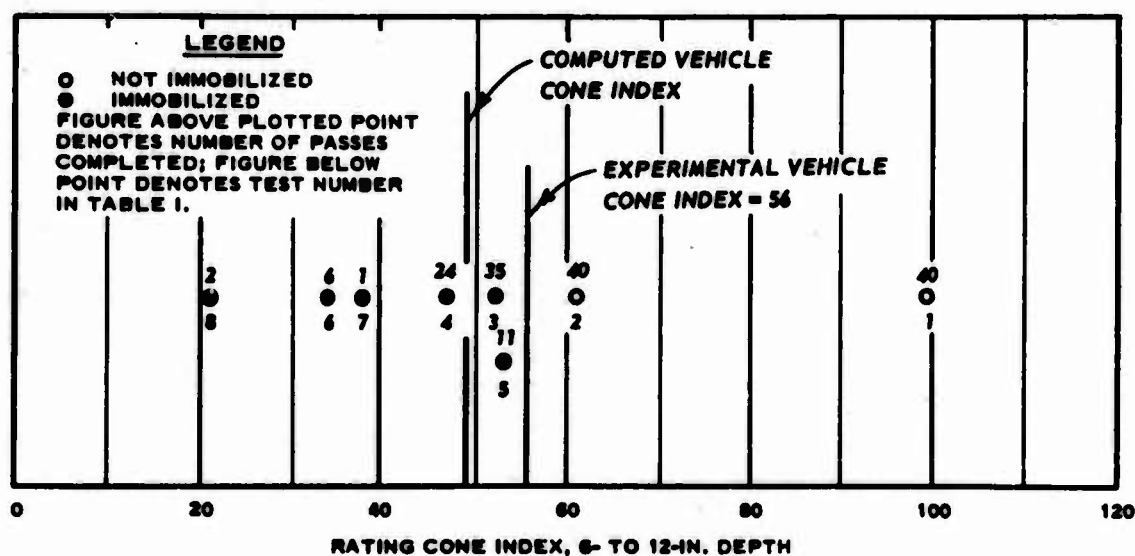


Fig. 7. Vehicle performance, tests in muck, 40- to 50-pass criteria

note (from table 1) that vehicle performance also correlates with the depth of the muck soil to a firm sand layer; i.e., when that depth was less than the ground clearance of the vehicle (16 in.) it was not immobilized, and when that depth was greater, the vehicle was immobilized. The data in table 1 also show that in general the strength of the soil is in inverse agreement with the depth to firm sand, that is, the deeper the sand layer, the lower the soil strength in the 6- to 12-in. layer.

15. Comparison of experimental with computed vehicle cone index.

From fig. 7, it is obvious that the vehicle did not perform as well as would be expected from a consideration of its computed vehicle cone index (49). In other words, no immobilizations would have been expected in tests 3 and 5 where the rating cone indexes were greater than 49. The formula used for computing the vehicle cone index was derived from tests on vehicles with tires no larger than 14.00-20 and possibly is not directly applicable to vehicles equipped with larger tires. In the only previous attempt by AMRC to test the applicability of the formula to vehicles with large tires, some doubt arose as to its exact applicability. In this previous instance, tests were conducted with a Tornadozer equipped with 21.00-25 tires. Results* indicated that the formula was applicable if, instead of 40 passes, 25 passes was selected as a criterion. The reason for this was that the Tornadozer has a wide, flat bottom pan which caused almost instant immobilization when it began to drag. As soon as the dragging began, the resistance created between the bottom of the pan and the soil became greater than the traction that the vehicle was developing. This was contrary to the conditions of testing under which the formula was developed in that initial dragging at about 25 passes was seldom an indication of immobilization before 40 passes. Consequently, in tests with the Tornadozer it was judged that the formula was applicable if the completion of 25 passes was accepted as the criterion of performance. Like the Tornadozer, the Jumbo truck has a wide, flat pan (covering the front drum axle and differential, fig. 8) and its immobilization was practically coincident with initial dragging of its pan.

16. In fig. 9 the data have been replotted with tests in which 25

* Unpublished.

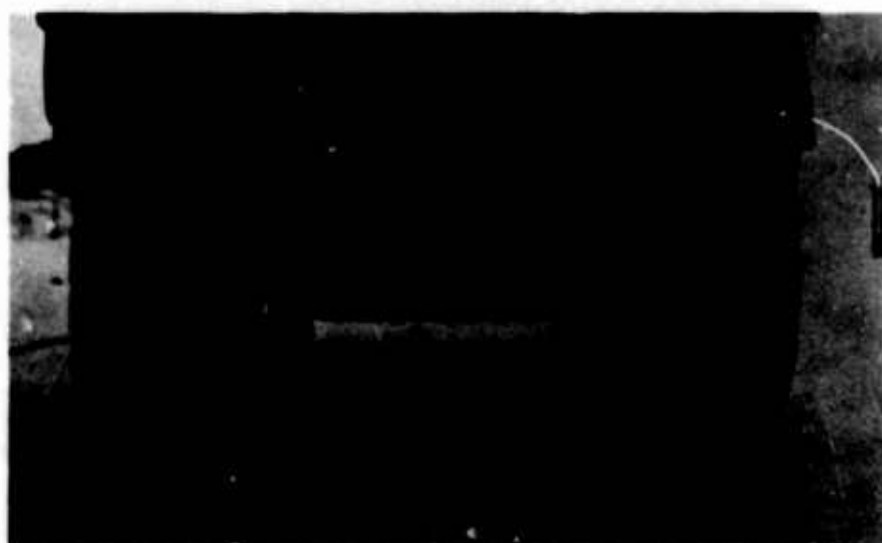


Fig. 8. Close-up of wide, flat pan covering front drum axle and differential of Jumbo truck

or more passes were completed considered to be "nonimmobilizations," and a line has been drawn at rating cone index = 49. Except for one test, the line neatly divides immobilizations and nonimmobilizations. Accordingly it is tentatively judged that the formula for wheeled vehicles is applicable to the Jumbo truck if the criterion of performance is revised to 25 passes

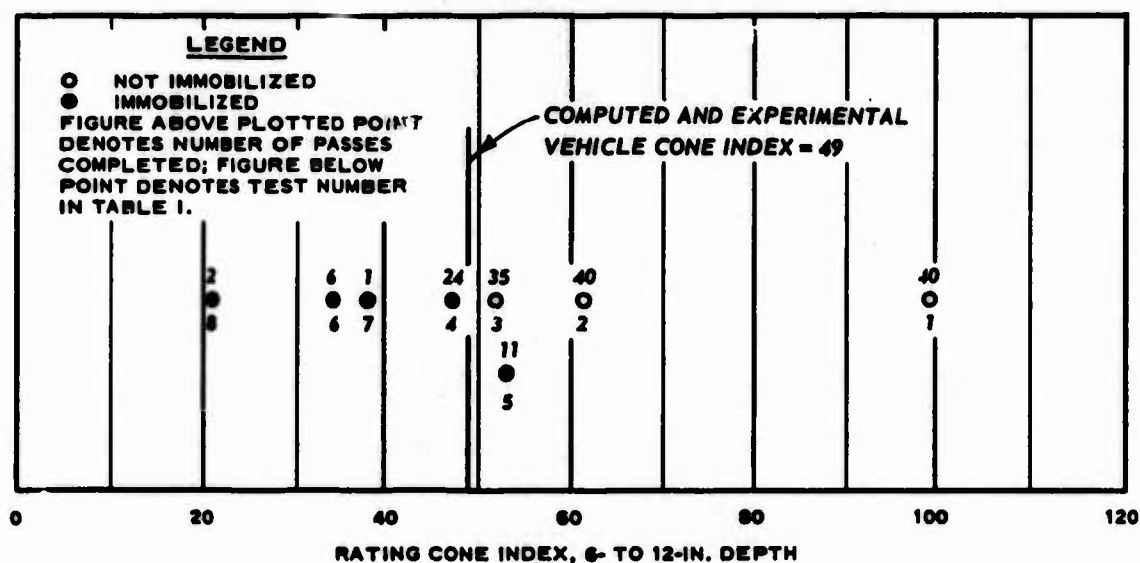


Fig. 9. Vehicle performance, tests in muck, 25-pass criteria

instead of 40 to 50. Further, it is believed likely that the formula would closely estimate the vehicle cone index on a 40- to 50-pass basis if the wide pan on the Jumbo were removed.

17. Comparison of cone index of Jumbo truck with those of similar vehicles. Even on the basis of its experimental cone index, 56, the Jumbo is clearly a better soft-ground-crossing vehicle than any other wheeled vehicle of its approximate size (weight) in the military system today. This may be verified by inspection of the vehicle cone indexes listed in Appendix A of TM 3-240, 14th Supplement.* Vehicles of comparable gross weights usually are 6x6's and are generally rated at vehicle cone indexes 10 to 15 points higher. One of the more mobile vehicles, an M135 2-1/2-ton 6x6 truck with 11.00-20 12-PR tires and a test weight of 18,750 lb, has a vehicle cone index of 65. The Jumbo probably compares favorably with GOER** vehicles, still in an experimental stage, but reported to have very good soft-ground-crossing ability. If the adverse effects of the wide front pan could be eliminated it is likely that the vehicle's soft-ground-crossing ability would be significantly improved, and its vehicle cone index would probably be in the order of 49 (for 40 passes).

18. Another feature that would undoubtedly improve the Jumbo would be a better distribution of its gross weight. The present model supports more than twice as much weight on its rear axle as on its front axle. This undoubtedly causes deeper rutting and thus reduces the number of passes the vehicle can accomplish in a given soil condition. The effect of the heavy rear end is well illustrated in fig. 10, which shows the Jumbo immobilized.

Sand tests

19. These tests were conducted to determine the slope-climbing ability of the Jumbo in a range of sand strengths (in the 0- to 6-in. depth) and slopes at tire-inflation pressures of from 30 to 10 psi.

* Op. cit.

** According to the brochure entitled "Wheeled Vehicles" which illustrates the application of the principles outlined in the Staff Study ATBEG 451 to President, Board No. 2, CONARC, and also in the Statement of Requirements, "GOERS," the term GOER "...has been chosen in lieu of truck or carrier, etc., so that vehicles meeting the requirements would be differentiated from existing standard trucks."



Fig. 10. Jumbo truck immobilized in muck (note how much deeper the rear end has sunk than the front)

20. Slope-climbing performance. Results of these tests are summarized in table 2 and shown graphically in fig. 11. The tests were limited to the slopes and strength combinations most nearly critical for the tire pressure being tested. For example, tests were not run on slopes which the vehicle obviously could travel with ease. Plotted in fig. 11 are results of tests with tire pressures of 30, 20, 15, and 10 psi, respectively. The curves drawn are the best visual fit to separate the immobilizations from the nonimmobilizations. These curves represent the maximum slope negotiable for the tire pressure considered, and are grouped in fig. 11 for ready comparison. Sand strength in the test area varied only between 50 and 100 cone index, but the range in slopes was wide. Shapes of the curves were influenced somewhat by similar curves for other wheeled vehicles.*

21. Comparison of performances of the Jumbo and M135 truck. In the following tabulation a comparison is made of the performance of the Jumbo and that of an M135 2-1/2-ton 6x6 truck with 11.00-20 12-PR tires, tested at 18,750 lb. In all tests the cone index was 100 in the top 6-in. layer.

* U. S. Army Engineer Waterways Experiment Station, CE, Trafficability of Soils, Tests on Coarse-Grained Soils with Self-propelled and Towed Vehicles, 1956 and 1957, Technical Memorandum No. 3-240, 15th Supplement (Vicksburg, Miss., June 1959).

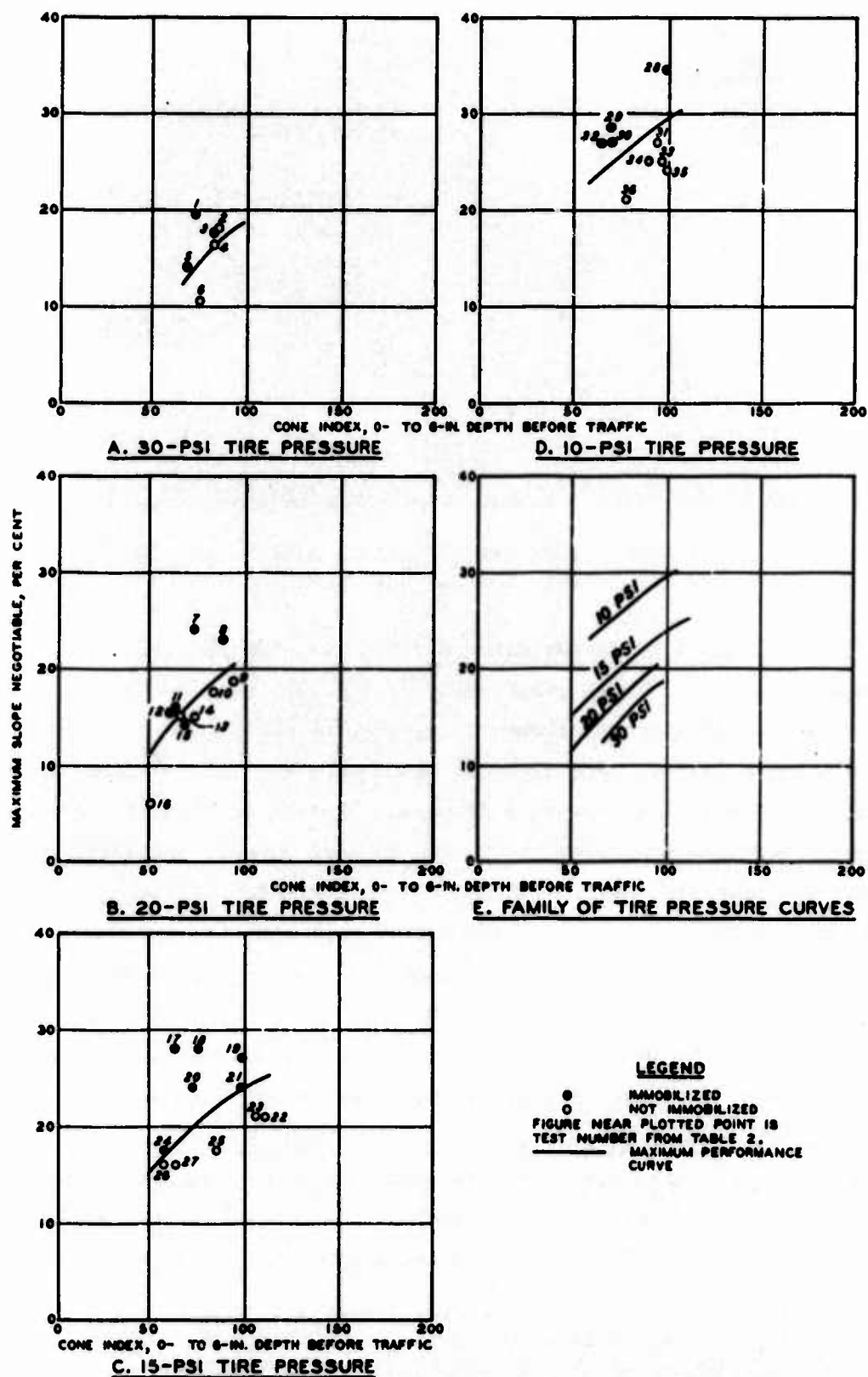


Fig. 11. Vehicle performance, tests in sand

<u>Tire Pressure, psi</u>	<u>Max Slope Negotiable, %</u>		
	<u>Jumbo</u>	<u>M135</u>	<u>Difference</u>
30	18.5	10.5	8.0
20	20.5	16.0	4.5
15	23.5	21.0	2.5
10	29.5	26.5	3.0

22. From the above tabulation it can be seen that the Jumbo with its large tires has better slope-climbing ability and thus better mobility in sands than the M135 truck at all tire pressures. It should also be noted that the large construction-equipment tires on the Jumbo have stiff sidewalls and deep, thick treads (fig. 12). These tires did not appear to deflect significantly at 15- and 10-psi tire pressures. The tire pressure could probably have been reduced to 5 psi without harmful results while the vehicle was operating on sand, thus increasing further its slope-climbing ability. A tire pressure of 10 psi is about the minimum on which the M135



Fig. 12. Large construction-equipment-type tires of the Jumbo truck

truck can operate without the tire sidewalls buckling or the tires slipping on their rims. Also, as in the muck tests, a better distribution of load on the Jumbo would have improved its performance.

Notes and Observations Made During Tests

Ground clearance

23. The ground clearance of 16.5 in. was measured from the bottom of the wide, flat, protective pan sloping beneath the steering linkages and

under the front differential and drive shaft. Although this pan affords protection against obstacles, such as tree stumps, an additional 6 in. of ground clearance could be obtained if it were eliminated. Its elimination would also reduce frictional resistance between the undercarriage and the soil when the truck begins to drag. The pan also acts as a scoop when the vehicle is traveling in reverse.

Excessive torque on
standard vehicle parts

24. The large-diameter tires mounted on the Jumbo apparently produced excessive torque on the rear axle, and on occasion, studs holding the wheel to the axle were sheared off when the wheels were allowed to spin in soft material. It was understood that the vehicle is equipped with standard drive shaft and axles.

Construction-equipment tires

25. These tires are exceptionally good for off-road operation, particularly in areas where rocks, logs, and tree stumps may be encountered, and also in soft soils. However, a tire with less sidewall stiffness would probably result in better performance in clean sand. The deep lugs also provide a certain amount of additional tire stiffness that detracts from its performance in sand.

Load distribution

26. It is again emphasized that a better distribution of load would undoubtedly improve performance in both muck and clean sand.

Conclusions and Recommendations

Conclusions

27. Based on results of the tests conducted, the following conclusions are offered:

- a. In muck tests, the Jumbo truck appeared to have performed somewhat less efficiently than would have been predicted from the computed vehicle cone index based on a 40-pass criterion for satisfactory performance. However, it performed in accordance with the computed vehicle cone index if a 25-pass criterion is used for satisfactory performance.
- b. The Jumbo truck can climb sand slopes steeper than can the standard M135 2-1/2-ton 6x6 cargo truck with 11.00-20 12-PR

tires, at equal tire pressures and cone indexes.

- c. Despite deficiencies in the form of poor weight distribution and high resistance to dragging resulting from its flat, wide, bottom pan, the Jumbo truck was found to be a better soft-ground-crossing vehicle than any comparable wheeled vehicle in the military supply system today.

Recommendations

28. Based on test results and the conclusions, it is recommended that:

- a. Trafficability tests be conducted in soft mineral soils with the Jumbo truck.
- b. Trafficability tests be conducted in soft snow with the Jumbo truck.
- c. Analysis of data from these and other tests of vehicles with large-diameter tires be made to determine if modification of the mobility index formula for wheeled vehicles is needed.

Table 1

Summary of Data and Test Results in Muck

Test No.	Immo- bilized	6- to 12-in. Layer Re- molding Index	Rating Cone Index	Average Moisture Content %	Average Dry Density lb/cu ft	Depth to Firm Sand in.	Remarks
1	No	0.76	99	56.4	63.1	15	Vehicle traveled with ease throughout test course; rut depth approximately 12 in. after 15 passes. Bottom of vehicle dragged on 30th pass but wheels were riding on sand layer. Made 40 passes with ease.
2	No	0.69	61	79.7	60.7	15	Vehicle dragged on 10th pass and rut depth was approximately 15 in. after 10 passes. Wheels were riding on sand layer. Made 40 passes with ease.
3	Yes	0.61	52	102.7	42.4	20	Rut depth increased gradually and vehicle started to drag undercarriage on 12th pass. Vehicle continued with some wheel slip until immobilization (36th pass). Rut depth was 16 in.
4	Yes	0.59	47	197.7	25.0	21	Rut depth progressed gradually. Some wheel slip occurred after 16 passes. Immobilized on 25th pass. Rut depth was 18 in.
5	Yes	0.64	53	164.1	28.2	24	Vehicle dragged on 8th pass and immobilized on 12th pass with 16-in. rut depth.
6	Yes	0.66	34	272.6	15.9	>24	Vehicle made 3- to 6-in. ruts on first pass and bottom dragged on 3d pass. Immobilized on 7th pass. Ruts at point of immobilization were 18 in. deep.
7	Yes	0.70	38	247.5	20.7	>24	Vehicle immobilized on 2d pass moving forward. Rut depth after the 2d pass was 28 in.
8	Yes	0.56	21	394.3	14.4	>24	Vehicle dragged on 1st pass and immobilized on 3d pass moving backward. Rut depth after the vehicle was retrieved was 27 in.

Note: To obtain cone index, divide rating cone index by remolding index.
 Moisture content and density are average of 0-in.- to 6-in.- and 6-in.- to 12-in.-layer data.
 Tire pressure, 30 psi.
 For all tests except No. 6 the vehicle made its first pass in reverse.

Table 2

Summary of Data and Test Results in Sand

Test No.	Tire Pressure psi	Slope %	<u>Immobilized</u>	Before-Traffic
				Average Cone Index 0- to 6-in. Depth
1	30	19-1/2	Yes	74
2		18	No	85
3		17-1/2	Yes	84
4		16-1/2	No	84
5		14	Yes	69
6		10-1/2	No	75
7	20	24	Yes	74
8		23	Yes	89
9		18-1/2	No	93
10		17-1/2	No	84
11		16	Yes	64
12		15	Yes	63
13		15	No	64
14		15	No	71
15		14	Yes	68
16		6	No	50
17	15	28	Yes	64
18		28	Yes	76
19		27	No	98
20		24	Yes	73
21		24	Yes	98
22		21	No	110
23		21	No	105
24		17-1/2	Yes	57
25		17-1/2	No	86
26		16	No	58
27		16	No	64
28	10	34-1/2	Yes	96
29		28-1/2	Yes	67
30		27	Yes	67
31		27	No	91
32		27	Yes	64
33		25	No	95
34		25	No	88
35		24	No	98
36		21	No	75

Note: Moisture classification, 0- to 6-in. depth, moist.

APPENDIX A: DETERMINATION OF VEHICLE CONE INDEX FOR THE
JUMBO TRUCK FOR OPERATION IN FINE-GRAINED SOILS

1. The determination of vehicle cone index for the Jumbo truck is described in detail in the following paragraphs. The first step in this determination is derivation of the mobility index.

Mobility Index

2. The mobility index is a number obtained by applying vehicle "factors" in the following formula for self-propelled wheeled vehicles.

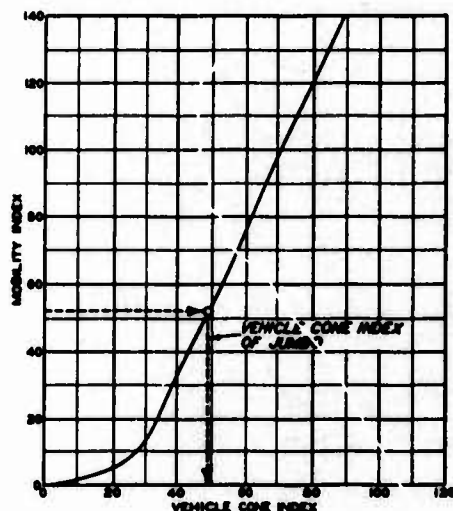
$$MI = 0.6 \left[\left(\frac{\text{contact pressure factor} \times \text{weight factor}}{\text{tire factor} \times \text{grouser factor}} + \frac{\text{wheel load} - \text{clearance factor}}{\text{factor}} \right) \times \text{engine factor} \times \text{transmission factor} \right] + 20$$

Vehicle Factor	Value
Contact pressure factor = $\frac{\text{gross weight, lb}}{\text{nom tire width, in.} \times \text{rim diam, in.} \times \text{No. of tires}}$ $= \frac{20,100}{18 \times 26 \times 4}$	10.74
Weight factor: 15,000 to 35,000 lb	1.00
Tire factor = $\frac{1.25 \times \text{nom tire width, in.}}{100} = \frac{1.25 \times 18}{100}$	0.225
Grouser factor: without chains	1.00
Wheel load = $\frac{\text{gross weight in kips}}{\text{No. of wheels}} = \frac{20}{4}$	5.00
Clearance factor = $\frac{\text{clearance, in.}}{10} = \frac{16.5}{10}$	1.65

(Continued)

Vehicle Factor		Value
Engine factor: $> \frac{10 \text{ hp}}{\text{ton}} : \frac{160}{10} = \frac{16.0 \text{ hp}}{\text{ton}}$	=	1.00
Transmission factor: mechanical	=	1.05
$MI = 0.6 \left[\left(\frac{10.74 \times 1.00}{0.225 \times 1.00} + 5.00 - 1.65 \right) \times 1.00 \times 1.05 \right] + 20 =$		52.18

The mobility index (MI) has been correlated with minimum strength requirements for conventional military vehicles (fig. A1).



Vehicle Cone Index

3. The vehicle cone index is the term applied to the minimum strength required in the critical soil layer for 40 to 50 passes of the vehicle. Through correlations between mobility index and test results, the curve shown in fig. A1 can be used to determine the vehicle cone index after the mobility index has been computed. From the curve it can be seen that the Jumbo truck has a vehicle cone index of 49.

Fig. A1. Vehicle cone index vs mobility index